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JOINT INDUSTRY STANDARD

Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount Devices

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The material in this joint standard was developed by the JEDEC JC-14.1 Committee on Reliability Test Methods for Packaged Devices and the IPC Plastic Chip Carrier Cracking Task Group (B-10a)

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Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount Devices

A joint standard developed by the JEDEC JC-14.1 Committee on Reliability Test Methods for Packaged Devices and the B-10a Plastic Chip Carrier Cracking Task Group of IPC

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Users of this standard are encouraged to participate in the development of future revisions.

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Handling, Packing, Shipping and Use of Moisture/ Reflow Sensitive Surface Mount Devices

1 FOREWORD

The advent of surface mount devices (SMDs) introduced a new class of quality and reliability concerns regarding package damage ''cracks and delamination'' from the solder reflow process. This document describes the standardized levels of floor life exposure for moisture/reflow-sensitive SMD packages along with the handling, packing and shipping requirements necessary to avoid moisture/reflow-related failures. Companion documents J-STD-020 and JEP113 define the classification procedure and the labeling requirements, respectively.

Moisture from atmospheric humidity enters permeable packaging materials by diffusion. Assembly processes used to solder SMD packages to printed circuit boards (PCBs) expose the entire package body to temperatures higher than 200°C. During solder reflow, the combination of rapid moisture expansion, materials mismatch, and material interface degradation can result in package cracking and/or delamination of critical interfaces within the package.

The solder reflow processes of concern are convection, convection/IR, infrared (IR), vapor phase (VPR) and hot air rework tools. The use of assembly processes that immerse the component body in molten solder are not recommended for most SMD packages.

1.1 Purpose The purpose of this document is to provide SMD manufacturers and users with standardized methods for handling, packing, shipping, and use of moisture/reflow sensitive SMD packages that have been classified to the levels defined in J-STD-020. These methods are provided to avoid damage from moisture absorption and exposure to solder reflow temperatures that can result in yield and reliability degradation. By using these procedures, safe and damage-free reflow can be achieved, with the dry packing process, providing a minimum shelf life capability in sealed dry-bags of 12 months from the seal date.

1.2 Scope

1.2.1 Packages

1.2.1.1 Nonhermetic This standard applies to all nonhermetic SMD packages subjected to bulk solder reflow processes during PCB assembly, including plastic encapsulated packages and all other packages made with moisture-permeable polymeric materials (epoxies, silicones, etc.) that are exposed to the ambient air.

1.2.1.2 Hermetic Hermetic SMD packages are not moisture sensitive and do not require moisture precautionary handling.

1.3 Assembly Processes

1.3.1 Mass Reflow This standard applies to bulk solder reflow assembly by convection, convection/IR, infrared (IR), and vapor phase (VPR) processes. It does not apply to bulk solder reflow processes that immerse the component bodies in molten solder (e.g., wave soldering bottom mounted components). Such processes are not allowed for many SMDs and are not covered by the component qualifications standards used as a basis for this document.

1.3.2 Localized Heating This standard also applies to moisture sensitive SMD packages that are removed or attached singly by local ambient heating, i.e., ''hot air rework.'' See Clause 6.

1.3.3 Socketed Components This standard does not apply to SMD packages that are socketed and not exposed to solder reflow temperatures. Such SMD packages are not at risk and do not require moisture precautionary handling.

1.3.4 Point-to-Point Soldering This standard does not apply to SMD packages in which only the leads are heated to reflow the solder, e.g., hand-soldering, hot bar attach of gull wing leads, and through hole by wave soldering. The heat absorbed by the package body from such operations is typically much lower than for bulk surface mount reflow or hot air rework, and moisture precautionary measures are typically not needed.

1.4 Reliability The methods set forth in this specification ensure that an adequate SMD package reliability can be achieved during and after the PCB assembly operation, when the SMD packages are evaluated and verified by J-STD-020 and/or by JESD22-A113 plus environmental reliability testing.

This specification does not address or ensure solder joint reliability of attached components.

1.5 Terms and Definitions

1.5.1 Active Desiccant Desiccant that is either fresh (new) or has been baked according to the manufacturer's recommendations to renew it to original specifications.

1.5.2 Bar Code Label The manufacturer's label that includes information in a code consisting of parallel bars and spaces or a 2D matrix format.

NOTE: For the purpose of this standard, the bar code label is on the lowest level shipping container and includes information that describes the product, e.g., part number, quantity, lot information, supplier identification, and moisture-sensitivity level.

1.5.3 Bulk Reflow Reflow of multiple components with simultaneous attachment by an infrared (IR), convection/IR, convection, or vapor phase reflow (VPR) process.

1.5.4 Carrier A container that directly holds components such as a tray, tube, or tape and reel.

1.5.5 Desiccant An absorbent material used to maintain a low relative humidity.

1.5.6 Floor Life The allowable time period after removal from a moisture barrier bag, dry storage or dry bake and before the solder reflow process.

1.5.7 Humidity Indicator Card (HIC) A card on which a moisture-sensitive chemical is applied such that it will make a significant, perceptible change in color (hue), typically from blue (dry) to pink (wet) when the indicated relative humidity is exceeded. The HIC is packed inside the moisture-barrier bag, along with a desiccant, to aid in determining the level of moisture to which the moisture-sensitive devices have been subjected.

1.5.8 Manufacturer's Exposure Time (MET) The maximum cumulative time after bake that components may be exposed to ambient conditions prior to shipment to end user.

1.5.9 Moisture Barrier Bag (MBB) A bag designed to restrict the transmission of water vapor and used to pack moisture-sensitive devices.

1.5.10 Rework The removal of a component for scrap, reuse, or failure analysis; the replacement of an attached component; or the heating and repositioning of a previously attached component.

1.5.11 Shelf Life The minimum time that a dry-packed moisture-sensitive device can be stored in an unopened moisture barrier bag (MBB) such that a specified interior bag ambient humidity is not exceeded.

1.5.12 SMD Surface Mount Device

Note: For the purpose of this standard, SMD is restricted to include only plastic-encapsulated SMDs and other packages made with moisture-permeable materials.

1.5.13 Solder Reflow A solder attachment process in which previously applied solder or solder paste is melted to attach a component to the printed circuit board.

1.5.14 Water Vapor Transmission Rate (WVTR) A measure of the permeability of plastic film or metallized plastic film material to moisture.

2 APPLICABLE DOCUMENTS

2.1 American Society for Testing and Materials (ASTM)[1]

ASTM F 1249 Standard Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor

ASTM F 392 Standard Test Method for Flex Durability of Flexible Barrier Materials

2.2 Electronic Industries Alliance (EIA, JEDEC)[2]

EIA-541 Packaging Material Standards for ESD Sensitive Items

JESD-625 Requirements for Handling Electrostatic Discharge Sensitive (ESD) Devices

JEP-113 Symbol and Labels for Moisture Sensitive Devices

JESD22-A113 Preconditioning of Nonhermetic Surface Mount Components Prior to Reliability Testing

JESD22-A120 Test Method for the Measurement of Moisture Diffusivity and Water Solubility in Organic Materials Used in Integrated Circuits

2.3 IPC Standards[3]

IPC-7711 Rework of Electronic Assemblies

IPC-7721 Repair and Modification of Printed Boards and Electronic Assemblies

2.4 Joint Industry Standards[4]

J-STD-020 Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices

2.5 Department of Defense[5]

MIL-PRF-81705 Type I - Barrier Materials Flexible. Electrostatic-free. Heat Sealable

MIL-D-3464 Type II - Desiccant, Activated, Bagged, Packaging Use and Static Dehumidification

3 DRY PACKING

3.1 Requirements Dry packing requirements for the various moisture sensitivity levels are shown in Table 3-1. The levels are determined per J-STD-020 and/or per JESD22-A113 plus reliability testing. As a minimum all materials used in dry packing should conform to EIA-541.

Table 3-1 Dry Packing Requirements

Level	Dry Before Bag	MBB With HIC	Desiccant	MSID* Label	Caution Label
1	Optional	Optional	Optional	Not Required	Not Required if classified at 220°C - 225°C Required** if classified at other than 220°C - 225°C
2	Optional	Required	Required	Required	Required
2a-5a	Required	Required	Required	Required	Required
6	Optional	Optional	Optional	Required	Required

*MSID = Moisture-Sensitive Identification Label

**A “Caution” label is not required if level and reflow temperature are given, in human readable form, on the barcode label attached to the lowest level shipping container.

1. www.astm.org
2. www.eia.org; www.jedec.org
3. www.ipc.org
4. www.eia.org; www.jedec.org; www.ipc.org
5. http://astimage.daps.dla.mil/quicksearch/

3.2 Drying of SMD Packages and Carrier Materials Before Being Sealed in MBBs

3.2.1 Drying Requirements - Levels 2a - 5a SMD packages classified at Levels 2a through 5a must be dried (see Clause 4) prior to being sealed in MBBs. The period between drying and sealing must not exceed the MET less the time allowed for distributors to open the bags and repack parts. If the supplier's actual MET is more than the default 24 hours, then the actual time must be used. If the distributor practice is to repack the MBBs with active desiccant, then this time does not need to be subtracted from the MET.

3.2.2 Drying Requirements - Carrier Materials Carrier materials, such as trays, tubes, reels, etc., that are placed in the MBB can affect the moisture level within the MBB. Therefore, the effect of these materials must be compensated for by baking or, if required, adding additional desiccant in the MBB to ensure the shelf life of the SMD packages.

3.2.3 Drying Requirements - Other Suppliers may use the drying effect of normal in-line processes such as post mold cure, marking cure, and burn-in to reduce the bake time. An equivalency evaluation is recommended to ensure that high temperature processing maintains moisture weight gain to an acceptable level. The total weight gain for the SMD package at the time it is sealed in the MBB must not exceed the moisture gain of that package starting dry and then being exposed to 30°C/60% RH for MET hours (less the time for distributors).

3.2.4 Excess Time Between Bake and Bag If the allowable time between bake and bag is exceeded, the SMD packages must be redried per Clause 4.

3.3 Dry Pack

3.3.1 Description Dry pack consists of desiccant material and a Humidity Indicator Card (HIC) sealed with the SMD packages inside a Moisture Barrier Bag (MBB). A representative dry pack configuration is shown in Figure 3-1.

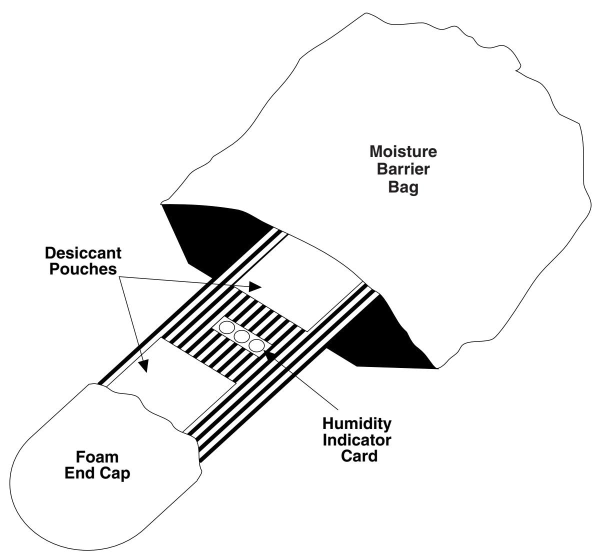


Figure 3-1 Typical Dry Pack Configuration for Moisture-Sensitive SMD Packages in Shipping Tubes

3.3.2 Materials

3.3.2.1 Moisture Barrier Bag (MBB) The moisture barrier bag **shall** meet MIL-PRF-81705, TYPE I requirements for flexibility, ESD protection, mechanical strength, and puncture resistance. The bags **shall** be heat sealable. The Water Vapor Transmission Rate (WVTR) **shall** be ≤0.002 gm/100 in^2 in 24 hrs at 40°C after flex testing per condition ''E''ASTM F 392. The WVTR is measured using ASTM F 1249.

3.3.2.2 Desiccant The desiccant material **shall** meet MIL-D-3464, TYPE II. Desiccant **shall** be dustless, noncorrosive, and absorbent to amounts specified in the standard. The desiccant **shall** be packaged in moisture permeable bags or pouches. The amount of desiccant used, per moisture barrier bag, **shall** be based on the bag surface area and WVTR in order to limit the interior relative humidity in the MBB to less than 10% at 25°C.

For comparison between various desiccant types, military specifications adopted the ''UNIT'' as the basic unit of measure of quantity for desiccant material. A UNIT of desiccant is defined as the amount that will absorb a minimum of 2.85 g of water vapor at 20% RH and 25°C.

When the desiccant capacity at 10% RH and 25°C is known the following equation should be used.

$$U = (0.304 * M * WVTR * A)/D$$

where:
U = Amount of desiccant in UNITS
M = Shelf life desired in months
WVTR = Water vapor transmission rate in grams/m^2 (grams/100 in^2) in 24 hrs
A = Total exposed surface area of the MBB in square meters (square inches)
D = The amount of water in grams, that a UNIT of desiccant will absorb at 10% RH and 25°C

When the desiccant capacity at 10% RH and 25°C is not known the quantity needed can be estimated using the following simplified equation.

$$U = 5 \times 10^{-3} A$$

where:
U = Amount of desiccant in UNITS
A = Total exposed surface area of the MBB in square inches

Note: No moisture-absorbing material (e.g., trays, tubes, reels, foam end caps) should be placed in the dry bag without baking. Any such material that is included increases the amount of desiccant needed to meet the calculated shelf life (see 5.3.1) by an amount based on the moisture content of the material. This can be determined by weighing a representative quantity of material known to be at equilibrium with the manufacturing environment, baking to a new constant weight, and subtracting the final from the initial weight.

Additional UNIT(s) of desiccant, based on 10% RH @ 25°C, must be added to absorb the amount of water, in grams, egressed from the packing materials (dunnage) after baking.

3.3.2.3 Humidity Indicator Card (HIC) At minimum, the HIC **shall** have three (3) color spots with sensitivity values of 5%, 10% RH and 60% RH. An example HIC is shown in Figure 3-2. The spots **shall** indicate the humidity with a significant, perceptible change in color (hue) as indicated in Table 3-2, when tested using the test method in Appendix A. The colors **shall** be described in writing on the card.

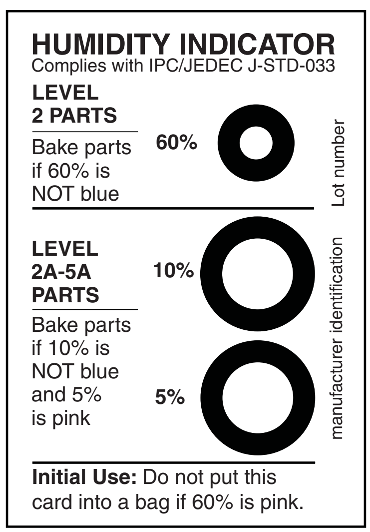


Figure 3-2 Example Humidity Indicator Card

3.3.2.4 HIC Paper White blotting paper made from fibrous cellulosic material, with a minimum basis weight of, 300 g/m^2 (equivalent to a nominal 200 pounds basis weight) **shall** be used for HICs.

3.3.2.5 Visual Defects HICs **shall** be free from defects including missing spots, tears, improperly located spots, and indicating color overrunning the black circles.

Table 3-2 Typical HIC Spot Compliance

	Indication at 2% RH Environment	Indication at 5% RH Environment	Indication at 10% RH Environment	Indication at 55% RH Environment	Indication at 60% RH Environment	Indication at 65% RH Environment
5% Spot	Blue (dry)	Lavender (spot value) **change ≥7% hue**	Pink (wet)	Pink (wet)	Pink (wet)	Pink (wet)
10% Spot	Blue (dry)	Blue (dry)	Lavender (spot value) **change ≥10% hue**	Pink (wet)	Pink (wet)	Pink (wet)
60% Spot	Blue (dry)	Blue (dry)	Blue (dry)	Blue (dry)	Lavender (spot value) **change ≥10% hue**	Pink (wet)

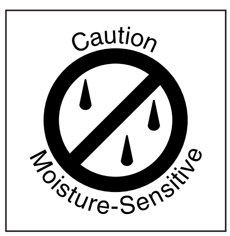
Note: Other color schemes may be used.

3.3.2.6 Preservation HICs **shall** be packaged in a moisture impervious container, typically a metal can containing 125 cards. Desiccant conforming to MIL-D-3464 **shall** be included in the container. At a minimum, the 10% spot **shall** indicate dry when the cards are packaged in the container.

3.3.2.7 Markings The container **shall** be marked with the part number, description, lot/date number, manufacturer name, quantity of cards, and IPC/JEDEC J-STD-033, including revision level.

3.3.3 Labels

3.3.3.1 Labels - Moisture Sensitive Identification Labels relevant to the dry pack process are the ''Moisture-Sensitive Identification'' (MSID) label and the Caution label as specified in JEDEC JEP113 (see Figures 3-3 and 3-4). The MSID label **shall** be affixed to the lowest-level shipping container that contains the MBB. The Caution label **shall** be affixed to the outside surface of the MBB. The Caution label includes fields for the Peak package body temperature allowed during reflow soldering (the classification temperature per J-STD-020), the floor life, and the bag seal date.



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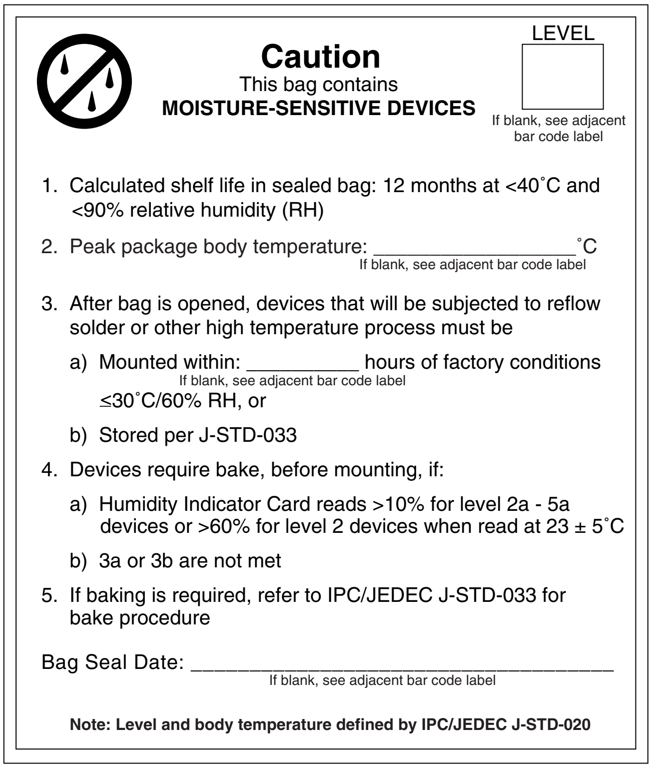
Figure 3-3 Moisture-Sensitive Identification Label (Example)

3.3.3.2 Labels - Level 6 Requirements Level 6 parts not shipped in MBBs **shall** have both an MSID label and the appropriate Caution label affixed to the lowest level shipping container.

3.3.3.3 Labels - Level 1 Requirements Level 1 parts classified for other than 220°C - 225°C maximum reflow temperature **shall** have a Caution label with the maximum reflow temperature specified. The Caution label **shall** be affixed to the MBB (if used) or to the lowest-level shipping container. The Caution label will not be required if a ''Bar Code'' label includes the Level 1 classification and maximum reflow temperature information in human readable form. Level 1 parts classified at 220°C - 225°C maximum reflow temperature do not require any moisture related labels.

3.3.4 Moisture Barrier Bag Sealing The bag should be heat sealed so as not to damage or cause delamination of the MBB. Full air evacuation is not needed or recommended; light air evacuation will reduce the packaging bulk and enhance carton packing. Excessive evacuation may impede desiccant performance and lead to MBB punctures.

3.3.5 Shelf Life The calculated shelf life for dry packed SMD packages **shall** be a minimum of 12 months from the bag seal date, when stored in a noncondensing atmospheric environment of <40°C/90% RH.



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Figure 3-4 Moisture-Sensitive Caution Label (Example)

4 DRYING

Component drying options for various moisture sensitivity levels and ambient humidity exposures of ≤60% RH are given in the following two tables. Drying per an allowable option resets the floor life clock. If dried and sealed in an MBB with fresh desiccant, the shelf life is reset. Tables 4-1, 4-2 and 4-3 give reference conditions for drying SMD packages. Table 4-1 gives conditions for rebake of SMD packages at a user site after the floor life has expired or other conditions have occurred to indicate excess moisture exposure. Table 4-2 gives conditions for bake prior to dry pack at a supplier and/or distributor and allows for a maximum total of 24 hour MET. Table 4-3 summarizes conditions for resetting or pausing the ''floor life'' clock at the user site per clause 4.1. The supplier **shall** formally communicate to the distributor the maximum time that the product may be left unsealed (at the distributor) before rebaking is required.

4.1 Post Exposure to Factory Ambient Placing SMD packages, which have been exposed to factory ambient conditions for greater than one hour, in a dry cabinet or dry pack does NOT necessarily stop/pause the floor life clock. However if the conditions of 4.1.2 are met the floor life clock can be paused or reset see; Table 4-3.

4.1.1 Any Duration Exposure Moisture sensitive SMD packages that have been exposed only to ambient conditions of ≤60% RH for any length of time may be adequately dried by high or low temperature baking according to Table 4-1 for rebake prior to reflow or Table 4-2 for drying prior to dry pack.

4.1.2 Short Duration Exposure Previously dry SMD packages, which have been exposed only to ambient conditions not exceeding 30°C/60% RH may be adequately dried by room temperature desiccation using dry pack or a dry cabinet. If dry pack is used and the total desiccant exposure is not greater than 30 minutes, the original desiccant may be reused.

4.1.2.1 Moisture Sensitivity Levels 2-3 For moisture sensitivity Levels 2, 2a, 3 with floor life exposure not greater than 12 hours, a minimum desiccating period of 5X the exposure time is required to dry the SMD packages enough to **reset** the floor life clock see Table 4-3. This can be accomplished by dry pack according to 3.3 or a dry cabinet that is capable of maintaining not greater than 10% RH.

For components exposed anytime less than their stated floor life; dry packing or placing the components in a dry cabinet, maintaining not greater than 10% RH, will **stop/pause** the floor life clock as long as the cumulative floor life meets the conditions in Table 5-1 and/or Table 7-1.

Table 4-1 Reference Conditions for Drying Mounted or Unmounted SMD Packages (User Bake: Floor life begins counting at time = 0 after bake)

Package Body	Level	Bake @ 125°C		Bake @ 90°C ≤5% RH		Bake @ 40°C ≤5% RH	
		Exceeding Floor Life by >72 h	Exceeding Floor Life by ≤72 h	Exceeding Floor Life by >72 h	Exceeding Floor Life by ≤72 h	Exceeding Floor Life by >72 h	Exceeding Floor Life by ≤72 h
Thickness ≤1.4 mm	2	5 hours	3 hours	17 hours	11 hours	8 days	5 days
	2a	7 hours	5 hours	23 hours	13 hours	9 days	7 days
	3	9 hours	7 hours	33 hours	23 hours	13 days	9 days
	4	11 hours	7 hours	37 hours	23 hours	15 days	9 days
	5	12 hours	7 hours	41 hours	24 hours	17 days	10 days
	5a	16 hours	10 hours	54 hours	24 hours	22 days	10 days
Thickness >1.4 mm ≤2.0 mm	2	18 hours	15 hours	63 hours	2 days	25days	20 days
	2a	21 hours	16 hours	3 days	2 days	29 days	22 days
	3	27 hours	17 hours	4 days	2 days	37 days	23 days
	4	34 hours	20 hours	5 days	3 days	47 days	28 days
	5	40 hours	25 hours	6 days	4 days	57 days	35 days
	5a	48 hours	40 hours	8 days	6 days	79 days	56 days
Thickness >2.0 mm ≤4.5 mm	2	48 hours	48 hours	10 days	7 days	79 days	67 days
	2a	48 hours	48 hours	10 days	7 days	79 days	67 days
	3	48 hours	48 hours	10 days	8 days	79 days	67 days
	4	48 hours	48 hours	10 days	10 days	79 days	67 days
	5	48 hours	48 hours	10 days	10 days	79 days	67 days
	5a	48 hours	48 hours	10 days	10 days	79 days	67 days
BGA package >17 mm x 17 mm or any stacked die package (See Note 2)	2-6	96 hours	As above per package thickness and moisture level	Not applicable	As above per package thickness and moisture level	Not applicable	As above per package thickness and moisture level

Note 1: Table 4-1 is based on worst-case molded lead frame SMD packages. Users may reduce the actual bake time if technically justified (e.g., absorption/desorption data, etc.). In most cases it is applicable to other nonhermetic surface mount SMD packages.

Note 2: For BGA packages >17 mm x 17 mm, that do not have internal planes that block the moisture diffusion path in the substrate, may use bake times based on the thickness/moisture level portion of the table.

Note 3: If baking of packages >4.5 mm thick is required see appendix B.

4.1.2.2 Moisture Sensitivity Levels 4, 5, 5a For moisture sensitivity Levels 4, 5, 5a with floor life exposure not greater than eight hours, a minimum desiccating period of 10X the exposure time is required to dry the SMD packages enough to reset the floor life clock see Table 4-3. This can be accomplished by dry pack according to 3.3 or a dry cabinet that is capable of maintaining not greater than 5% RH.

Once the floor life clock has been reset, refer to 5.3 for safe storage conditions.

4.2 General Considerations for Baking The oven used for baking **shall** be vented and capable of maintaining the required temperatures at less than 5% RH.

4.2.1 High Temperature Carriers Unless otherwise indicated by the manufacturer, SMD packages shipped in high temperature carriers can be baked in the carriers at 125°C.

4.2.2 Low Temperature Carriers SMD packages shipped in low temperature carriers may not be baked in the carriers at any temperature higher than 40°C. If a higher bake temperature is required, SMD packages must be removed from the low temperature carriers to thermally safe carriers, baked, and returned to the low temperature carriers.

Note 1. Manual handling may increase the risk of mechanical and/or ESD damage.

Note 2. If SMD packages are placed in dry bags with unbaked carriers, refer to 3.3.2.2.

4.2.3 Paper and Plastic Container Items Paper and plastic container items such as cardboard boxes, bubble pack, plastic wrap, etc., **shall** be removed from around the carriers prior to baking. Rubber bands around tubes and plastic tray ties must also be removed prior to high temperature (125°C) bake.

Table 4-2 Default Baking Times Used Prior to Dry-Pack that were Exposed to Conditions ≤60% RH (Supplier Bake: "MET" = 24 h)

Package Body Thickness	Level	Bake @ 125°C	Bake @ 150°C
≤1.4 mm	2	7 hours	3 hours
	2a	8 hours	4 hours
	3	16 hours	8 hours
	4	21 hours	10 hours
	5	24 hours	12 hours
	5a	28 hours	14 hours
>1.4 mm ≤2.0 mm	2	18 hours	9 hours
	2a	23 hours	11 hours
	3	43 hours	21 hours
	4	48 hours	24 hours
	5	48 hours	24 hours
	5a	48 hours	24 hours
>2.0 mm ≤4.5 mm	2	48 hours	24 hours
	2a	48 hours	24 hours
	3	48 hours	24 hours
	4	48 hours	24 hours
	5	48 hours	24 hours
	5a	48 hours	24 hours

Note 1: If baking of packages >4.5 mm thick is required see appendix B.

Note 2: The bake times specified are conservative for packages without blocking planes or stacked die. For a stacked die or BGA package with internal planes that impede moisture diffusion the actual bake time may be longer than that required in Table 4-2 if packages have had extended exposure to factory ambient before bake. Also the actual bake time may be reduced if technically justified. The increase or decrease in bake time **shall** be determined using the procedure in JEDEC JESD22-A120 (i.e., <0.002% weight loss between successive readouts) or per critical interface concentration calculations.

Table 4-3 Resetting or Pausing the "Floor Life" Clock at User Site

MSL Level	Exposure Time @ Temp/Humidity	Floor Life	Desiccator Time @ Relative Humidity	Bake	Reset Shelf Life
2, 2a, 3, 4, 5, 5a	Anytime ≤40°C/85% RH	reset	NA	Table 4.1	Dry Pack
2, 2a, 3, 4, 5, 5a	> floor life ≤30°C/60% RH	reset	NA	Table 4.1	Dry Pack
2, 2a, 3	>12 hrs ≤30°C/60% RH	reset	NA	Table 4.1	Dry Pack
2, 2a, 3	≤12 hrs ≤30°C/60% RH	reset	5X exposure time ≤10% RH	NA	NA
4, 5, 5a	>8 hrs ≤30°C/60% RH	reset	NA	Table 4.1	Dry Pack
4, 5, 5a	≤8 hrs ≤30°C/60% RH	reset	10X exposure time ≤5% RH	NA	NA
2, 2a, 3	Cumulative time ≥ floor life ≤30°C/60% RH	pause	Anytime ≤10% RH	NA	NA

4.2.4 Bakeout Times Bakeout times start when all SMD packages reach the specified temperature.

4.2.5 ESD Protection Proper ESD handling precautions should be observed, per EIA-625. This is particularly critical if SMD packages are manually handled by vacuum pencils under low humidity conditions, e.g., in a dry environment, after baking, etc.

4.2.6 Reuse of Carriers The appropriate materials specification should be consulted before reusing carriers.

4.2.7 Solderability Limitations

4.2.7.1 Oxidation Risk Baking SMD packages may cause oxidation and/or intermetallic growth of the terminations, which if excessive can result in solderability problems during board assembly. The temperature and time for baking SMD packages are therefore limited by solderability considerations. Unless otherwise indicated by the supplier, the cumulative bake time at a temperature greater than 90°C and up to 125°C **shall not** exceed 96 hours. If the bake temperature is not greater than 90°C, there is no limit on bake time. Bake temperatures higher than 125°C are not allowed without consulting the supplier.

4.2.7.2 Carrier Out-gassing Risk Care should be taken to ensure that out-gassing of materials from the component carriers does not occur to any significant extent, such that solderability might be affected.

5 USE

Upon opening the MBB, the floor life clock starts. If an MBB is opened and the SMD packages will not be used within the specified floor life, the procedures in Clause 7 should be followed.

5.1 Incoming Bag Inspection

5.1.1 Upon Receipt Dry packed SMD packages should be inspected for a bag seal date located on the caution or bar code label to determine remaining shelf life. The bags should be inspected to verify there are no holes, gouges, tears, punctures or openings of any kind that would expose either the contents or an inner layer of a multilayer bag. If openings are found, and the humidity indicator card (HIC) indicates maximum humidity has been exceeded, then the parts should be baked for 48 hours at 125°C or using the saturated bake times of Table 4-1.

5.1.2 Component Inspection Intact bags may be opened for component inspection by cutting at the top of the bag near the seal. If the bags are opened under factory ambient conditions, (see 4.1.2).

5.2 Floor Life The floor life of SMDs per Table 5-1 will be modified by environmental conditions other than 30°C/60% RH. Refer to Clause 7 to determine maximum allowable time before rebake would be necessary. If partial lots are used, the remaining SMD packages must be resealed or placed in safe storage within one hour of bag opening (see 5.3). If one hour exposure is exceeded, refer to 4.1.

Table 5-1 Moisture Classification Level and Floor Life

Level	Floor Life (out of bag) at factory ambient ≤30°C/60% RH or as stated
1	Unlimited at ≤30°C/85% RH
2	1 year
2a	4 weeks
3	168 hours
4	72 hours
5	48 hours
5a	24 hours
6	Mandatory bake before use. After bake, must be reflowed within the time limit specified on the label.

5.3 Safe Storage ‘Safe storage’ means dry SMD packages held in a controlled humidity condition such that the floor life clock remains at zero. Acceptable safe storage conditions for SMD packages classified as Level 2 through 5a are listed below.

5.3.1 Dry Pack Dry packed SMD packages in intact MBBs, stored per 3.3, **shall** have a calculated shelf life of at least 12 months from the bag seal date shown on the caution or bar code label.

5.3.2 Shelf Life The minimum calculated shelf life is 12 months from bag seal date. If the actual shelf life has exceeded 12 months and the humidity indicator card (HIC) (see 5.5.1) indicates that baking is not required, then it is safe to reflow the components per the original MSL rating. Although unanticipated, factors other than moisture sensitivity could affect the total shelf life of components.

Note: An HIC that has been continuously sealed in the MBB is typically accurate up to five years.

5.3.3 Dry Atmosphere Cabinet Storage cabinets which maintain low humidity by purging with dry air or nitrogen at 25 ± 5°C. The cabinets must be capable of recovering to their stated humidity rating within one hour from routine excursions such as door opening/closing.

5.3.3.1 Dry Cabinet at 10% RH SMD packages not sealed in a MBB may be placed in a dry atmosphere cabinet, maintained at not greater than 10% RH. These dry cabinets should not be considered a MBB. Storage of SMD packages in these dry cabinets should be limited to a maximum time per Table 7-1. If the time limit is exceeded they should be baked according to Table 4-2 to restore the floor life.

5.3.3.2 Dry Cabinet at 5% RH SMD packages not sealed in a MBB may be placed in a dry atmosphere cabinet, maintained at not greater than 5% RH. Storage in these dry cabinets may be considered equivalent to storage in a MBB with unlimited shelf life.

5.4 Reflow Reflow includes single and multi-pass assembly reflow and single component attach/removal for rework.

5.4.1 Opened MBB After a dry pack (MBB) has been opened, all SMD packages within that bag must complete all solder reflow processing, including rework, prior to the stated floor life, resealed in the MBB, or stored in a dry atmosphere cabinet per 4.1. If the floor life or factory ambient conditions are exceeded, refer to 5.5.2.

5.4.2 Reflow Temperature Extremes During reflow the component body temperature must not exceed the rated value, stated on the Caution label. The body temperature during reflow directly influences component reliability.

Note 1. The component body temperature may be very different from the lead or solder ball temperature, particularly in IR and IR/convection processes, and should be checked separately.

Note 2. Some hot air attach processes may require heating the component body to temperatures hotter than 225°C. If that temperature exceeds the classification temperature, moisture precautions and/or time-temperature limitations beyond the scope of this specification may be required. The supplier should be consulted.

5.4.3 Additional Thermal Profile Parameters During reflow, the additional thermal profile parameters stated in JESD22-A113 should not be exceeded. Although the body temperature during reflow is the most critical parameter, other profile parameters such as the total exposure time to hot temperatures, and the heating rates, may also influence component reliability.

5.4.4 Multiple Reflow Passes If more than one reflow pass is used, care must be taken to ensure that no moisture sensitive SMD packages, mounted or unmounted, have exceeded their floor life prior to the final pass. If any component on the board has exceeded its floor life the board needs to be baked prior to the next reflow. Clause 6 should be referenced for the baking of populated boards.

Note: The floor life clock is NOT reset by any reflow or rework process.

For cavity packages in which water may be entrapped, water clean processes after the first reflow can be an additional source of moisture. This may present an additional risk, which should be evaluated.

5.4.5 Maximum Reflow Passes A maximum of three reflow passes is allowed per component. If more than three are required for any reason, the supplier must be consulted (reference J-STD-020).

5.5 Drying Indicators Events and conditions, that require component drying prior to reflow or continued safe storage.

5.5.1 Excess Humidity in the Dry Pack Excess humidity in the dry pack is noted by the humidity indicator card (HIC). It can occur due to misprocessing (e.g., missing or inadequate desiccant), mishandling (e.g., tears or rips in the MBB), or improper storage.

The HIC should be read immediately upon removal from the MBB. For best accuracy, the HIC should be read at 23 ± 5°C. The following conditions apply regardless of the storage time, i.e., whether or not the shelf life has been exceeded.

Note: ''Witness'' cards may be available from the HIC manufacturer if needed to confirm the wet/dry colors.

5.5.1.1 HIC Indication 1 If the 5%, 10% and 60% RH spots indicate dry, then Levels 2, 2a 3, 4, 5, and 5a parts are still adequately dry. If the bag is to be resealed refer to 4.1.

5.5.1.2 HIC Indication 2 If the 5% RH spot indicates wet and the 10% RH spot does not indicate dry, and the 60% spot indicates dry, the Levels 2a, 3, 4, 5, and 5a have been exposed to an excessive level of moisture, and drying **shall** be done per Clause 4. Level 2 parts are still adequately dry

5.5.1.3 HIC Indication 3 If the 5%, 10%, and 60% RH spots indicate wet, Level 2 parts have been exposed to an excessive level of moisture, and drying **shall** be done per Clause 4.

Note: Discard HICs where the 60% spot indicates wet.

5.5.2 Floor Life or Ambient Temperature/Humidity Exceeded If the floor life or ambient temperature/humidity conditions per Table 5-1 have been exceeded, SMD packages must be dried per Clause 4 prior to reflow or safe storage.

If the factory ambient temperature and/or humidity conditions per Table 5-1 cannot be met, the component floor life must be derated to compensate. Floor life derating is discussed in Clause 7.

5.5.3 Level 6 SMD Packages SMD packages classified as Level 6 must be dried by baking, then reflowed within the time limit specified on the label.

6 BOARD REWORK

6.1 Component Removal, Rework and Remount If a component is to be removed from the board, it is recommended that localized heating be used and the maximum body temperatures of any surface mount component on the board not exceed 200°C. This method will minimize moisture related component damage. If any component temperature exceeds 200°C, the board must be baked dry per 6.2 prior to rework and/or component removal. Component temperatures **shall** be measured at the top center of the package body. Any SMD package that has not exceeded its floor life can be exposed to a maximum body temperature as high as its maximum reflow temperature as defined by J-STD-020.

6.1.1 Removal for Failure Analysis Not following the requirements of 6.1 may cause moisture/reflow damage that could hinder or completely prevent the determination of the original failure mechanism.

6.1.2 Removal and Remount Removal and reinstallation or replacement of a component should be conducted following IPC-7711 or IPC-7721. If a component is to be removed and reinstalled it may be necessary to first bake the printed wiring assembly to eliminate moisture from the component. Table 4-1 may be used as a guide in identifying an appropriate bake cycle. When identifying a bake cycle the maximum exposure temperature and maximum rate of temperature change of components and materials on the subject printed wiring assembly must be considered and an appropriate time temperature profile (see IPC-7711) used. An SMD package **shall not** exceed its MSL ratings per J-STD-020 at any time during replacement. Localized replacement reflow heating is recommended, so that the entire board is not re-subjected to reflow temperature profiles.

Note: Temperatures on neighboring SMD packages above the melting point of the solder being used may cause some solder joints to partially reflow, which may result in a potential solder joint reliability concern.

6.2 Baking of Populated Boards A default board assembly bake-out temperature of 125°C **shall** be used, except in cases where components and/or board materials cannot withstand this condition. Examples of temperature sensitive components include organic LEDs, batteries and electrolytic capacitors. With component and board temperature restrictions in mind, choose a bake temperature from Table 4-1; then determine the appropriate bake duration based on the component to be removed. For additional considerations see IPC-7711 and IPC-7721.

7 DERATING DUE TO FACTORY ENVIRONMENTAL CONDITIONS

Factory floor life exposures for SMD packages removed from the dry bags will be a function of the ambient environmental conditions. A safe, yet conservative, handling approach is to expose the SMD packages only up to the maximum time limits for each moisture sensitivity level as shown in Table 5-1. This approach, however, does not work if the factory humidity or temperature is greater than the testing conditions of 30°C/60% RH. A solution for addressing this problem is to derate the exposure times based on the knowledge of moisture diffusion in the component packaging materials (ref. JESD22- A120). Recommended equivalent total floor life exposures can be estimated for a range of humidities and temperatures based on the worst case exposure conditions and the nominal plastic thickness for each device. Table 7-1 lists equivalent derated floor lives for humidities ranging from 5-90% RH for temperatures of 20°C, 25°C, 30°C and 35°C. This table is applicable to SMDs molded with novolac, biphenyl or multifunctional epoxy mold compounds. The following assumptions were used in calculating Table 7-1:

1. Activation Energy for diffusion = 0.35eV (smallest known value).
2. For ≤60% RH, use Diffusivity = 0.121exp (- 0.35eV/kT) mm^2/s (this uses smallest known Diffusivity @ 30°C).
3. For >60% RH, use Diffusivity = 1.320exp (- 0.35eV/kT) mm^2/s (this uses largest known Diffusivity @ 30°C).

Table 7-1 Recommended Equivalent Total Floor Life (days) @ 20°C, 25°C & 30°C, 35°C For ICs with Novolac, Biphenyl and Multifunctional Epoxies (Reflow at same temperature at which the component was classified) Maximum Percent Relative Humidity

Package Type and Body Thickness	Moisture Sensitivity Level	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	
Body Thickness ≥3.1 mm including PQFPs >84 pins, PLCCs (square) All MQFPs or All BGAs ≥1 mm	**Level 2a**	∞	∞	94	44	32	26	16	7	5	4	35°C
		∞	∞	124	60	41	33	28	10	7	6	30°C
		∞	∞	167	78	53	42	36	14	10	8	25°C
		∞	∞	231	103	69	57	47	19	13	10	20°C
	Level 3	∞	∞	8	7	6	6	6	4	3	3	35°C
		∞	∞	10	9	8	7	7	5	4	4	30°C
		∞	∞	13	11	10	9	9	7	6	5	25°C
		∞	∞	17	14	13	12	12	10	8	7	20°C
	Level 4	∞	3	3	3	2	2	2	2	1	1	35°C
		∞	5	4	4	4	3	3	3	2	2	30°C
		∞	6	5	5	5	5	4	3	3	3	25°C
		∞	8	7	7	7	7	6	5	4	4	20°C
	Level 5	∞	2	2	2	2	1	1	1	1	1	35°C
		∞	4	3	3	2	2	2	2	1	1	30°C
		∞	5	5	4	4	3	3	2	2	2	25°C
		∞	7	7	6	5	5	4	3	3	3	20°C
	Level 5a	∞	1	1	1	1	1	1	1	1	1	35°C
		∞	2	1	1	1	1	1	1	1	1	30°C
		∞	3	2	2	2	2	2	1	1	1	25°C
		∞	5	4	3	3	3	2	2	2	2	20°C
Body 2.1 mm ≤ Thickness <3.1 mm including PLCCs (rectangular) 18-32 pins SOICs (wide body) SOICs ≥20 pins, PQFPs ≤80 pins	**Level 2a**	∞	∞	∞	∞	58	30	22	3	2	1	35°C
		∞	∞	∞	∞	86	39	28	4	3	2	30°C
		∞	∞	∞	∞	148	51	37	6	4	3	25°C
		∞	∞	∞	∞	∞	69	49	8	5	4	20°C
	Level 3	∞	∞	12	9	7	6	5	2	2	1	35°C
		∞	∞	19	12	9	8	7	3	2	2	30°C
		∞	∞	25	15	12	10	9	5	3	3	25°C
		∞	∞	32	19	15	13	12	7	5	4	20°C
	Level 4	∞	5	4	3	3	2	2	1	1	1	35°C
		∞	7	5	4	4	3	3	2	2	1	30°C
		∞	9	7	5	5	4	4	3	2	2	25°C
		∞	11	9	7	6	6	5	4	3	3	20°C
	Level 5	∞	3	2	2	2	2	1	1	1	1	35°C
		∞	4	3	3	2	2	2	1	1	1	30°C
		∞	5	4	3	3	3	3	2	1	1	25°C
		∞	6	5	5	4	4	4	3	3	2	20°C
	Level 5a	∞	1	1	1	1	1	1	1	0.5	0.5	35°C
		∞	2	1	1	1	1	1	1	0.5	0.5	30°C
		∞	2	2	2	2	2	2	1	1	1	25°C
		∞	3	2	2	2	2	2	2	2	1	20°C
Body Thickness <2.1 mm including SOICs <18 pins All TQFPs, TSOPs or All BGAs <1 mm body thickness	**Level 2a**	∞	∞	∞	∞	∞	∞	17	1	0.5	0.5	35°C
		∞	∞	∞	∞	∞	∞	28	1	1	1	30°C
		∞	∞	∞	∞	∞	∞	∞	2	1	1	25°C
		∞	∞	∞	∞	∞	∞	∞	2	2	1	20°C
	Level 3	∞	∞	∞	∞	∞	8	5	1	0.5	0.5	35°C
		∞	∞	∞	∞	∞	11	7	1	1	1	30°C
		∞	∞	∞	∞	∞	14	10	2	1	1	25°C
		∞	∞	∞	∞	∞	20	13	2	2	1	20°C
	Level 4	∞	∞	∞	7	4	3	2	1	0.5	0.5	35°C
		∞	∞	∞	9	5	4	3	1	1	1	30°C
		∞	∞	∞	12	7	5	4	2	1	1	25°C
		∞	∞	∞	17	9	7	6	2	2	1	20°C
	Level 5	∞	∞	7	3	2	2	1	1	0.5	0.5	35°C
		∞	∞	13	5	3	2	2	1	1	1	30°C
		∞	∞	18	6	4	3	3	2	1	1	25°C
		∞	∞	26	8	6	5	4	2	2	1	20°C
	Level 5a	∞	7	2	1	1	1	1	1	0.5	0.5	35°C
		∞	10	3	2	1	1	1	1	1	0.5	30°C
		∞	13	5	3	2	2	2	1	1	1	25°C
		∞	18	6	4	3	2	2	2	2	1	20°C

∞ Represents indefinite exposure time allowed at conditions specified.

Appendix A
Test Method for Humidity Indicator Card used with Electronic Component Packaging

Note: It is intended to make the HIC test method and criteria a separate standard in the future.

HIC Testing Method To function properly, the spots must show a visually perceptible color change to indicate a change in the amount of humidity. This testing method uses a colorimeter to measure the color (hue) of humidity indicating spots. The percentage of change in hue from one humidity value to another is then calculated.

Testing Apparatus A test environment capable of maintaining atmosphere at a temperature of 23 ± 1°C and a relative humidity from 2% to 65% ± 1. The cards inside the chamber must be observable from outside the chamber. Nominally, an acrylic box with a volume of approximately 2 cubic feet, having facilities for access to the box interior while maintaining atmosphere is used. Refer to Figure A-1. Humidity conditions can be achieved by placing combinations of molecular sieve desiccant, glycerin and water inside the chamber.

A colorimeter capable of measuring L, a*, and b* values (AccuProbe HH06, Accuracy Microsensors, Pittsford, NY or equivalent).

An electronic hygrometer, with the minimum range of 1 to 90% RH.

Testing Procedure Place the sealed container of cards into the chamber. Set the chamber to the first humidity listed in Table 3-2. Open the container and suspend two cards inside the chamber so that the spots can be observed from outside the chamber. Allow the cards to condition for 24 hours. All testing occurs inside the chamber, while the cards are exposed to the test humidity. Using a colorimeter, measure and record the L, a*, and b* values for each spot on the cards. Set the chamber for the next humidity and continue in this manner until data has been collected for all conditions.

Note: Printing in the indicating spot (colored area) will affect hue measurement. Spots without printing **shall** be tested.

Data Analysis Using the a* and b* data, calculate the hue value for each spot at each humidity condition in Table 3-2 where:

If a* and b* are negative then:

Hue = the absolute value of ARCTAN(b*/a*)

If a* and b* are positive, or if a* is positive and b* is negative then:

Hue = 180 + ARCTAN(b*/a*)

If a* is negative and b* is positive then:

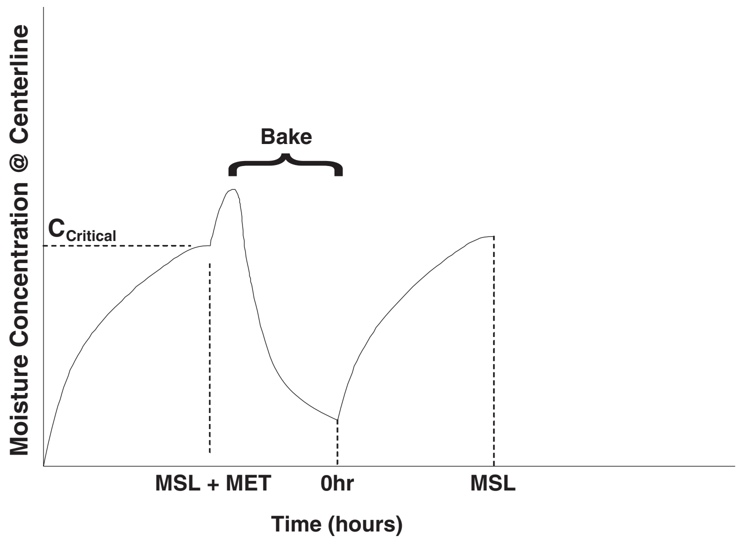
Hue = 360 + ARCTAN(b*/a*)

Calculate the percent change in hue value at the humidity values shown in table 3-2. Accept cards that show a 10% or greater change in hue value from one humidity to the next. Cards with spots that do not indicate 'dry' or 'wet' conditions, per Table 3-2, should be rejected.



Figure A-1 Photo of Testing Apparatus

Appendix B
Derivation of Bake Tables



Bake Tables 4.1 and 4.2 were calculated using the following assumptions/approach:

1. Assume Fickian 1-D diffusion and Henry's Law apply:

$$\frac{\partial C}{\partial t} = D \frac{\partial^2 C}{\partial x^2} \text{ (Fick's Law)}$$

C_{Sat} (@ surface) ∝ % RH in ambient atmosphere (Henry's Law)

Where C as a function of time (t) is:

$$C(t) = C_{Sat} \left(1 - \frac{4}{\pi} \sum_{n=0}^{\infty} \left\{ \frac{(-1)^n}{(2n+1)} e^{-D\,(2n+1)^2 \pi^2 t \,/\, 4L^2} \right\} \right)$$

2. Diffusivity = 6.2 exp(-0.445eV/kT) mm^2/s, (assumes slow diffusing mold compound)
   a. $D_{30C} = 2.48 x 10^{-7}$ mm^2/s
   b. $D_{40C} = 4.27 x 10^{-7}$ mm^2/s
   c. $D_{90C} = 4.13 x 10^{-6}$ mm^2/s
   d. $D_{125C} = 1.44 x 10^{-5}$ mm^2/s

3. Define:
   a. $\mathbf{L}_{centerline}$ = critical thickness, e.g., thickness of package / 2
   b. $C_{Critical}$ = concentration at $\mathbf{L}_{centerline}$ for given MSL (based on 30°C/60% RH exposure + 24 hr MET preconditioning)
   c. $C_{Centerline}$ = concentration at $\mathbf{L}_{centerline}$ for any exposure condition

4. Impose following two exposure conditions:
   a. MSL + >72 hr exposure (assume saturated at 30°C/85% RH where C_{Sat} = 7.8 mg/cm^3)
   b. MSL + ≤72 hr exposure (assume ambient at 30°C/60% RH where C_{Sat} = 5.3 mg/cm^3

5. Calculate minimum time @ Bake temperature for cases 4a and 4b where an additional MSL exposure will keep $C_{Centerline}$ < $C_{Critical}$.

Ref: R. L. Shook and J. P. Goodelle, ''Handling of Highly-Moisture Sensitive Components - An Analysis of Low-Humidity Containment and Baking Schedules,'' ECTC, 1999, pp. 809-15.

Appendix C
Amendment 1 - Differences between J-STD-033B.1 and J-STD-033B

Amendment 1 has been incorporated into J-STD-033B.1 to describe changes that appear in this standard compared to its predecessor, J-STD-033B (October 2005).

Page	Reference	J-STD-033B	Amendment 1
5	Figure 3-2	J-STD-003B	J-STD-033
9	Table 4-2 Title	≥60% RH	≤60% RH
9	Table 4-3 Row 4 Column 1	2a, 3, 4	2, 2a, 3
	Table 4-3 Row 5 Column 1	2, 2a, 3, 4	2, 2a, 3
	Table 4-3 Row 6 Column 1	5, 5a	4, 5, 5a
	Table 4-3 Row 7 Column 1	5, 5a	4, 5, 5a
	Table 4-3 Row 7 Column 2	≥8 hrs	≤8 hrs

Standard Improvement Form

IPC/JEDEC J-STD-033B.1

The purpose of this form is to provide the Technical Committee of IPC with input from the industry regarding usage of the subject standard.

Individuals or companies are invited to submit comments to IPC. All comments will be collected and dispersed to the appropriate committee(s).

If you can provide input, please complete this form and return to:

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E-mail: answers@ipc.org

1. I recommend changes to the following:

   ___ Requirement, paragraph number __________

   ___ Test Method number __________, paragraph number __________

   The referenced paragraph number has proven to be:

   ___ Unclear ___ Too Rigid ___ In Error

   ___ Other ______________________________

2. Recommendations for correction:

   ____

   ____

   ____

   ____

3. Other suggestions for document improvement:

   ____

   ____

   ____

   ____

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